



## **Open C Type Permanent Magnet With Two Columns For Magnetic Resonance**

### BACKGROUND OF THE INVENTION

#### Field of the Invention

The present invention generally relates to a medical apparatus, and more particularly to a permanent magnet used for magnetic resonance imaging for medical diagnosis.

#### Brief Description of the Prior Arts

The magnetic resonance imaging apparatus is a medical apparatus developed in 1980's, and the most advanced clinical diagnosis apparatus for diagnosing precancer and other diseases. The magnet is a key part of the magnetic resonance imaging apparatus, SNR (signal-to-noise ratio) of the magnetic resonance imaging apparatus has a direct relation to the performance of the magnet, so that performance of the magnet determines the quality of the image to a certain extent. The permanent magnet has a simple structure without additional means and is convenient to maintain, can be operated safely, and area of the stray magnetic field therearound is small, therefore, the scientific and technological circles and medicine circles pay more and more regards for the magnetic resonance imaging apparatus using permanent magnet.

However, the conventional box-shape permanent magnet formed of ferrite magnetic material is low in magnetic intensity, heavy, big in volume, closed and poor in practicability. In the early stage, weight of a magnet of 3000Gs is substantially 100 ton, so that it is difficult to transport and mount the magnet.

SUBSTITUTE SPECIFICATION  
CLEAN COPY

Subsequently, a new magnetic material, i.e. NdFeB, is developed, many countries invest a lot of work and money in research and development of the magnetic resonance permanent magnet having low field strength. Recently, there is proposed a magnet of so-called open type which has high magnetic energy product, good uniformity, and small volume, this type magnet has the following advantageous: a patient can lie on a half-open examining table, thus eliminating the patient's dread occurring in the conventional MRI examination, so that it is easily acceptable for children or other peevish patients. In addition, during the MRI examination, the patient is not required to lie on or lie face down on the examining table, and be seated on the table that they may be examined on a part of the body thereof such as extremities. In addition, it is possible to provide interventional therapy to the patient. Therefore, this type magnet has developed rapidly and a lot of products are available on the market. Since this type magnet is cheap, the market share thereof has increased gradually. However, the above conventional products have a separated structure, the yoke part of the magnet is formed by a plurality of portions assembled to each other, therefore, it is difficult to ensure parallelism of the upper yoke to the lower yoke during manufacturing and assembling, thus deteriorating the performance of the magnet to a certain extent, more particularly, decreasing the mechanical strength of the magnet and affecting the uniformity of the magnetic circuit.

SUMMARY OF THE INVENTION

Accordingly, in order to solve problems occurring in the conventional magnets formed by a plurality of parts assembled to each other, an object of the present invention is to provide an

SUBSTITUTE SPECIFICATION  
CLEAN COPY

open-type permanent magnet for magnetic resonance, which has a substantially C-shaped structure with two columns.

The above object is accomplished by providing a permanent magnet comprising: a yoke, magnetic materials, pole heads, plates for vortex, i.e. eddy currents, rings for homogenizing magnetic field, and gradient coils. The yoke of the present invention is integrally formed by casting, has a substantially C-shaped and open structure with two columns, the magnetic material is adhesive bonded to the yoke, the pole heads are adhesive bonded to the yoke, plates for eliminating vortex are adhesive bonded to the pole heads respectively, and the gradient coils and rings for homogenizing magnetic field are mounted to the pole heads respectively, with the gradient coils located inside and the rings for homogenizing magnetic field located outside, each of the rings for homogenizing magnetic field is respectively formed of a plurality of arc sections fixed to the pole heads so as to form a ring.

The magnet of the present invention is integrally formed by casting, which has a substantially C-shaped and open structure with two columns, so that it is simply in a single structure. The magnetic circuit thereof is designed by two-dimensional or three-dimensional simulation using a computer, the magnetic material is formed of consubstantial NdFeB using a series of high and new-technologies and processes, thus ensuring good uniformity and stability, small area of the stray magnetic field, and eliminating substantially vortex effect, i.e. eddy currents. The yoke part of the present invention is formed integrally of low carbon steel by casting, the material forming the yoke part is uniform, the crystal grains of the yoke part are uniform and consistent as a result of annealing the material

SUBSTITUTE SPECIFICATION  
CLEAN COPY

forming the yoke part twice, thus eliminating the internal stress completely. The defects in the yoke part can be eliminated by magnetic particle and ultrasonic inspection, so that the parallelism of the lower yoke to the upper yoke can be ensured to the maximum extent, thus increasing mechanical strength of the yoke frame and ensuring uniformity of the magnetic field and fluency of the magnetic circuit. At the same time, the yoke frame is designed as a streamline shape and thereby meets the requirements of the design principle of the magnetic circuit of the magnet, so that the magnet is light, has low flux leakage and good appearance. The magnet of the present invention employs NdFeB as the magnetic material having high performance, thus increasing uniformity of the magnet and eliminating the vortex (i.e. eddy currents) effect generally occurring in conventional permanent magnet. The base magnetic field is good, so that the magnetic field can be homogenized easily.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view of the integral structure of the magnet according to one embodiment of the present invention;

Fig. 2 is a side view of the Fig. 1.

reference numerals 1: a yoke; 2: magnetic material; 3: pole head; 4: plate for eliminating vortex, (i.e. eddy currents); 5: field-homogenizing ring; 6: gradient coil

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

As shown in Fig. 1, the magnet of the present invention comprises a yoke 1, magnetic material 2, pole heads 3, plates

SUBSTITUTE SPECIFICATION  
CLEAN COPY

for eliminating vortex 4, rings 5 for homogenizing magnetic field, and gradient coils 6. The yoke 1 has an integral, substantially C-shaped and opened structure with two columns. The magnetic material 2 is adhesive bonded to the yoke 1, the pole heads 3 are adhesive bonded to the magnetic material 2 respectively, the plates for eliminating vortex 4 are adhesive bonded to the pole heads 3 respectively, the gradient coils 6 and rings 5 for homogenizing magnetic field are fixed to the pole heads 3 by screws respectively.

The technical indicators of the magnet according to the present invention are provided in the following table:

type	2300	3500
magnetic field intensity	2300Gs $\pm$ 50Gs	3500Gs $\pm$ 50Gs
magnetic field direction	vertical	vertical
height of air gap	525mm	525mm
material	NdFeB	NdFeB
structure	open	open
5Gs line	$\leq$ 1.8m	$\leq$ 2.2m
uniformity of magnetic field	$\leq$ 20ppm in 30DSV	$\leq$ 20ppm in 30DSV
homogenizing manner	passive	passive
stability	6ppm/h	6ppm/h
operating condition	21 $\pm$ 1 $^{\circ}$ C	21 $\pm$ 1 $^{\circ}$ C